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FROM
EXPERIMENT STATIONS

SEASON 1952-53

COTTON RESEARCH STATION
NAMULONGE, UGANDA

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COTTON RESEARCH STATION, NAMULONGE

PROGRESS REPORT FOR THE SEASON 1952-53

CROP CALENDAR

	Cotton	*Food Crops*
Sowing	Mid June to end August	January-April
Flowering	September-November	—
Reaping	December-March	May-August

Introduction

BY

J. B. HUTCHINSON.

The Namulonge Advisory Board met on the two days 18th and 19th November 1952. The 18th was spent in the laboratories and the field discussing the work in progress, and the Board meeting followed on the morning of the 19th. 189 visitors signed the Visitors' Book, and 9 large parties, of about 25 persons each, spent a day on the station during the year.

The unstinted help of the Departments of Agriculture of the territories served is again acknowledged. Free exchange of comment and information, together with the generous welcome accorded to members of the staff on safari, have kept the station in close touch with conditions in the field.

Visits were paid by members of the staff to the following territories:—

Kenya, Nyanza.—By Dr. Hutchinson, Mr. Manning, Mr. Geering and Mr. Prentice.

Kenya, Coast.—By Dr. Hutchinson.

Nyasaland.—By Dr. Hutchinson.

Tanganyika, Ukiriguru.—By Mr. Le Mare.

Uganda, Serere.—By Mr. Geering, Mr. Le Mare and Mr. Evenson.

Zanzibar.—By Dr. Hutchinson.

Two conferences were attended:—

Plant Breeding conference at Nakuru and Njoro, Kenya.—By Dr. Hutchinson and Mr. Manning.

Soils and Fertilizers Conference at E.A.A.F.R.O. Headquarters, Muguga, Kenya.—By Mr. Manning, Mr. Farbrother and Mr. Le Mare. Mr. Le Mare read a paper on fertilizer trials carried out on O.F.C. farms.

A meeting between members of the Corporation's staff at Namulonge and Ukiriguru was arranged by Mr. Peat at Ukiriguru, and attended by Messrs. MacDonald, Geering, Farbrother and Le Mare from Namulonge.

Mr. K. S. McKinlay, insecticide entomologist on the staff of the East African Agricultural and Forestry Research Organisation, continued his work at Namulonge in the year under report. This co-opera-

tion in insecticide problems is greatly appreciated. By courtesy of the Director, E.A.A.F.R.O., he has contributed to the entomological section of this report.

A research studentship in Plant Breeding tenable for six months at Namulonge and three months at Ukiriguru has been held by Mr. D. A. Lawes.

The Farm

BY

A. L. STEPHENS.

The general layout of the farm has been modified considerably by the inclusion, as arable land, of some of the lower slopes which exceed the 6% slope originally set as a maximum. Two factors contributed to the decision to include these, the first being the success of tie-ridging, when properly done, as an anti-erosion measure, and the second the need to make the layout more compact and therefore less vulnerable to the depredations of monkeys and other vermin. These were proving a serious menace under the original ridge top layout, with the elephant grass and bush covered slopes providing cover. The steeper slopes, having previously been used principally for annual cropping, were much less of a problem to clear than the ridge tops, where most of the African housing and permanent crops had been situated.

New cultivation in 1952 consisted of 32 acres of ridge top which had been cleared in 1951 but which was cropped for the first time in 1952, and an area of 27 acres which was opened up in 1952 and cropped with maize as an indicator crop prior to the use of the block for rotation experiments. Yields were poor, but the crop provided useful information on fertility variations. In addition, two blocks of 31 and 24 acres were cleared ready for cropping in 1953 and three paddocks of 37 acres in all were cleared of bush and fenced.

The cleared area at Namulonge now amounts to 480 acres, made up of:—

Arable: Cropped	192 acres		
Cleared for 1953, but not cropped in 1952	55 acres		
Paths	28 acres	= 275	acres
Meteorological Station and grass plots		5	„
Orchard and steading		2	„
Gum plantation		40	„
Paddocks		45	„
Housing, laboratory and recreation area		113	„ *

The arable area, much of which was cropped twice during the year, provided 62 acres of cotton, 33 acres of first rains maize, 50 acres of

*Includes 60 acres regularly grazed, and 15 acres of staff shambas.

second rains maize, and the balance of the acreage in cassava, sweet potatoes, bananas, groundnuts and beans. Yields of food crops, with the exception of some cassava planted in 1951 and harvested in 1952, were much below average owing to the exceptionally dry weather, which also delayed much of the cotton planting. Two strains of cotton, namely BP52.NC51 and BP52.NC52, were handled by the farm for bulk increase and planted over a period of three months. A comparison of yields from the various sowing dates is given elsewhere in the report.

Mechanisation of the farm has continued to be a question of adaptation and invention. The only mounted maize and cotton planter available in East Africa, the Massey Harris "433", required some modification before it could be used with our Fordson Major tractors. A prototype of a mechanically operated furrow-tier for mounting behind the ridging bodies on a Fordson toolbar has been designed and made in the workshop, and tested. The first design, though satisfactory on the level, has some disadvantages on rough or sloping land. With some modification it should be a more generally effective implement.

The herd was supplemented by the purchase of eleven heifers early in the year. Later 24 cows and heifers were bought, with 23 of their progeny. These were culls from the herds of the Veterinary Research farm. As they came from a tick free farm, the adult animals were subject to some risk from East Coast Fever, and in fact seven have since died. Up to the end of the year the demand for milk still exceeded the supply, and all animals in milk were milked. Careful milk records are being kept. One cow completed a lactation (305 days) of over 210 gallons and suckled her calf, a probable capacity of 300 gallons, while another has exceeded 175 gallons and suckled her calf. Bad milkers are marked for culling when the milk supply position permits, and it is intended that they shall be run as a range herd with calves at foot.

The bullock herd, consisting of 17 bullocks obtained from the Veterinary Research farm at the end of 1950 and 12 of our own breed, suffered a setback and lost weight in June and July. The net increment in liveweight for the twelve months was nearly 160 lb. per beast with no supplementary feeding. Pending the increase of this herd to reasonable proportions, the local demand for meat was met by purchasing Ankole cattle from a dealer in that district. Weight records of these animals have been kept in order to get some information on their reaction to the change in environment, and 22 which were kept for two months or over had a mean liveweight increase of 27 lb. per beast per month over an average period of nearly four months. Altogether fifty-four Ankole cattle were killed and the killing out-turn averaged 42 per cent.

TABLE 1.

SUMMARY OF METEOROLOGICAL DATA FOR 1952-53.

Month	Rainfall		Evaporation		Relative Humidity		Sunshine		Temperature		
	Ins.	Days >0·01	Open‡ Pan	F.A.O. Pan	a.m.	p.m.	Hours* per Day	Callender Units per Day	Mean Max.	Mean Min.	Av. of
June	0·71	5	4·68	—	80·5	56·8	6·58	693·1	81·8	61·1	71·5
July	1·62	7	4·22	—	83·7	54·2	5·43	613·0	81·5	60·1	70·8
August	2·35	14	4·20	—	82·3	58·9	4·62	577·1	81·0	60·5	70·8
September	3·11	13	4·20	—	80·3	56·0	5·71	688·6	83·0	60·5	71·8
October	3·11	10	4·21	—	74·9	53·3	5·91	677·4	83·5	61·8	72·7
November	3·22	14	3·60	4·49	76·7	54·8	5·88	665·1	83·2	61·5	72·4
December	0·26	3	6·58	7·35	60·0	30·9	8·53	809·4	89·1	59·4	74·3
January	1·73	6	5·70	6·34	67·7	38·1	7·30	677.2	87·1	59·8	73·4
February	0·79	3	7·02	7·56	60·9	31·8	7·87	798.8	90·2	58·8	74·6
Sums	16·90	75	44·41	—	—	—	—	—	—	—	—
Means	—	—	—	—	74·1	48·3	6·43	688·8	84·5	60·4	72·5
March	2·65	10	5·09	6·91	69·3	49·4	7·01	738·7	87·3	63·6	75·5
April	6·23	14	2·89	4·50	81·1	59·7	4·99	655·6	82·8	63·9	73·6
May	5·29	17	3·37	4·40	83·6	63·3	7·05	724·0	82·0	63·1	72·6
Sums	31·07	116	55·76	—	—	—	—	—	—	—	—
Means	—	—	—	—	75·1	50·6	6·41	693·2	84·4	61·2	72·8

‡Diameter 22 ins. *Campbell-Stokes.

Climatology

BY

H. L. MANNING AND H. G. FARBROTHER.

Standard meteorological data for the year are summarised in Table 1. This table makes an interesting comparison with the similar table of the previous report. The open water surface evaporation for the nine months' period June to February was about 30 inches in 1950-51, 33 inches in 1951-52, and from Table 1 is shown to have been over 44 inches in 1952-53. This, together with unusually high mean values of daily sunshine and very low afternoon relative humidities, is an adequate indication of the sustained dry conditions which were a dominant feature of the second half of the year.

Further information is now available on losses from run-off from a bare soil at a slope not exceeding 2 per cent. (that is, agriculturally flat land), and that from a similar area covered with a grass mulch no deeper than 4 inches. Between November 1951 and April 1953, 110 storms of not less than 0·25 inches were studied. Of these 23 were of more than 1 inch per storm. There were 4 of these exceeding 2 inches per storm. Run-off actually measured from the undisturbed bare soil was 37·8 inches (some 44 per cent.) whereas that from the mulch was only 4·4 inches (some 5 per cent.). Thus the relation between rainfall and the soil moisture available to the growing plant may be enormously complicated by the effect on run-off losses of conditions above the soil surface.

Climatologically the three years 1950-52 were very different. The rainfall totals at the Namulonge meteorological station were 60·0 inches for 1950, 70·5 inches for 1951 and only 36·1 inches for 1952. Only 6 years of records are now available at Namulonge so that calculations of confidence limits are of little value, but it is of interest to note that the two latter values are outside the upper and lower 9 : 1 limits for the Bukalasa Experiment Station, 20 miles away, for which 30 years of records are available. It might be expected that cotton yields in the three seasons would reflect at least the major differences in rainfall, but in fact only very limited associations between rainfall and yield can be detected. Yield data for farm scale cotton crops in the three years are tabulated by sowing date in Table 2, together with data for March-May (presowing) rainfall, and rainfall for the 6 months from planting of each crop.

For June sowings, yield levels were not as different as might have been expected from the great difference in annual rainfall totals. The striking difference between years is in the date to which sowing could be postponed without a heavy drop in yield. In the first year of the series, the drop was heavy from sowings in the third fortnightly period (the figure for the second fortnight was an estimate, and must be dis-

TABLE 2.

SEED COTTON YIELDS OF BP52 STRAINS FOR THREE SEASONS.

First or pre-sowing rains for March, April and May.
Second or post-sowing rains, total for six months after sowing.

Sowing Period	*1950-51 First Rains 23·46″*			*1951-52 First Rains 26·65″*			*1952-53 First Rains 17·83″*			*Mean Yield p.a.*	*Per cent. June 1-15*
	Yield p.a.	*Per cent. June 1-15*	*Second Rains*	*Yield p.a.*	*Per cent. June 1-15*	*Second Rains*	*Yield p.a.*	*Per cent. June 1-15*	*Second Rains*		
June 1-15	961(3·0)†	100	24·58	1150(1·1)	100	32·12	920(3·9)	100	14·13	1010	100
June 16-30	800*	83	23·56	1163(5·4)	101	35·46	983(3·2)	107	13·63	982	97
July 1-15	582(3·8)	61	23·56	1072(0·4)	93	36·70	1015(3·8)	110	13·68	890	88
July 16-31	575(5·4)	60	23·27	1145(1·2)	100	36·01	679(1·4)	74	14·77	800	79
Aug. 1-15	474(3·4)	49	23·86	831(1·7)	72	33·95	562(7·7)	61	13·79	622	62
Aug. 16-31	251*	26	21·62	772(1·4)	67	34·96	277(5·2)	30	12·75	433	43

*Estimated by Missing Plot Technique. †Figures in brackets are acreages from which yields were calculated.

Analysis of variance.

Due to	*d.f.*	*S.S.*	*M.S.*	*F.*	*p.*
Seasons	2	539375·0	269687·5	17·11	<0·01
June vs. July and August	1	384193·3	384193·3	24·38	<0·01
July vs. August	1	301150·0	301150·0	19·11	<0·01
Between Fortnights in months	3	66935·6	22311·9	1·41	N.S.
Error	8*	126080·1	15760·0		
Total	17	1417734·0			

* 2 d.f. lost from missing plots.

counted). In the second year, yields from sowings in all the first four periods, and in the third year in the first three periods, were well maintained. Once the yield decline began, it went on at much the same rate in all years.

The relation between yield and rainfall is highly complex, but in view of its importance, an attempt was made to devise a hypothetical relationship that might be put to the test. Evidently rainfall was not the major factor determining the yield of timely sown cotton in any of the three seasons, and it may therefore be supposed that the differences in annual totals experienced by those crops were largely balanced by water stored in the soil and subsoil profile, within the range of cotton roots. The fall in yield with later sowing may be ascribed to progressive depletion of the soil moisture reserves before cotton planting. Then the long maintenance of yield in 1951-52 would be due to the maintenance of subsoil reserves by copious mid year rains. The 1950-51 figures are difficult to interpret, as two figures have been interpolated by the missing plot technique. Though useful in making possible an analysis of variance, such estimates cannot be used in an attempt to study the shape of the yield × sowing date curve. On the rainfall figures, however, it would have been expected that the yields from sowings in the first half of July would have been at least as well maintained in 1950-51 as they were in 1952-53, when much less rain fell. In fact the yields in the former year dropped to 61 per cent. of yields from early June sowing. Evidently a fuller interpretation of yield variation in terms of water supply must await the estimation of soil moisture reserves.

Estimates of the more important soil constants governing the availability of moisture to plants have been made during the past two years, and are summarised in Table 3. Determinations were made in the laboratory except where otherwise stated, on soil from auger drillings made for gravimetric moisture determinations. Stones and gravel were removed, if present.

TABLE 3.

SATURATION CAPACITY, FIELD CAPACITY, AND WILTING POINT OF NAMULONGE SOILS AS PERCENTAGE MOISTURE BY WEIGHT.

1. *Saturation capacity.*

Percentage moisture.	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*Mean.*
Topsoil. Sept. 1950	3	2	8	3	2	—	—	32·3
Subsoil. April 1952	—	—	—	—	—	1	3	36·1

2. *Field Capacity.*

Percentage Moisture.	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*Mean.*
Topsoil. April 1951	1	—	1	2	3	1	—	—	—	25·5x
April 1952	—	—	4	3	—	—	—	—	—	24·8x
April 1953	2	3	1	—	1	1	—	—	—	24·1x
Subsoil. April 1952	—	—	—	—	—	—	—	2	1	30·0

x Determinations on field samples, bare soil.

3. *Wilting Point.*

Percentage moisture.	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*Mean.*
Topsoil. April 1951	4	—	2	—	—	—	—	—	—	—	—	9·2
July 1951	—	1	4	3	1	—	—	—	—	—	—	10·9
April 1953	—	2	1	4	5	—	—	—	—	—	—	11·6
Subsoil. April 1952	—	—	—	—	—	—	—	—	6	—	1	16·5

The figures for wilting point obtained in April 1951 are lower than those obtained later. This discrepancy is probably due to inexperience in detecting wilting points. The later figures may be taken as more reliable. Supporting evidence on wilting point is provided by moisture determinations on subsoil under cotton that was wilting in the early morning in December 1952. Two 6 ft. profiles averaged 15·1 and 17·9 per cent. moisture.

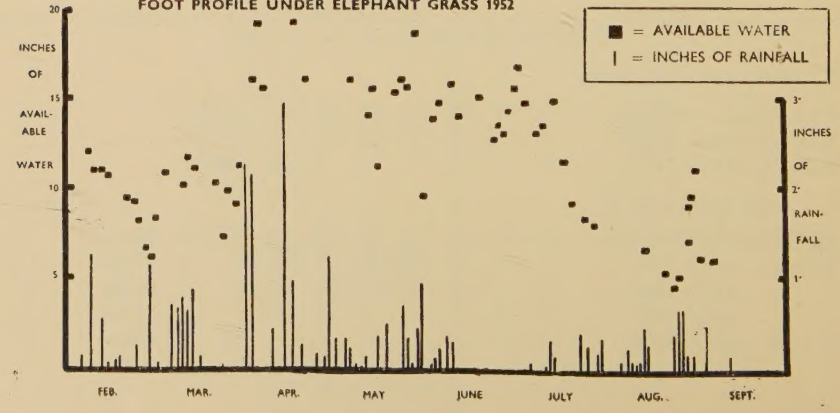
Apparent specific gravity determinations on dry soil gave 1·06 for topsoil and 1·16 for subsoil. Considering then a 10 ft. profile comprising 1 ft. of topsoil and 9 ft. of subsoil, an estimate may be made of the water held between field capacity and wilting point, which is approximately the amount of water available to growing plants. Taking the difference between field capacity and wilting point as roughly 14 per cent. in each case, the available water in a 10 ft. profile at field capacity will be about 19 inches.

Samples for the gravimetric determination of moisture content were taken from auger drillings to 10 ft. made daily under elephant grass from February to October 1952, and again in February 1953. The study was limited to 10 ft. depth because it was not possible to drill further with the equipment available. It is known that the root range of elephant grass exceeds 10 ft. but since the root range of the crops to which it is hoped to extend the study does not exceed 6-8 ft., it is believed that sampling to 10 ft. will be sufficient.

Estimates of the available moisture in the 10 ft. profile, together with rainfall data for the period of the auger drilling, are plotted in Fig. 1.

FIG. 1

RAINFALL AND AVAILABLE MOISTURE IN A TEN FOOT PROFILE UNDER ELEPHANT GRASS 1952



The data show the extreme heterogeneity of the soil in moisture content, but they nevertheless show the seasonal trend of moisture reserves. It will be seen that in February 1952 there was still a fair supply of available moisture presumably carried over from the previous very wet year. With the onset of the main rains, this supply was augmented, and in April approached the calculated maximum for available water in the 10 ft. profile (19 inches). Thereafter there was a steady decline until August, followed by a slight increase with the second rains. From September onwards the soil was extremely hard, and it was not until February 1953 that the technical difficulties of auger drilling in dry soil were overcome. In February four profiles were obtained, as follows:—

To 5 ft. 13·2 and 15·8 per cent. moisture.
To 7 ft. 16·3 per cent. moisture.
To 10 ft. 14·8 per cent. moisture.

It will be seen that, by February 1953, the moisture status down to 10 ft. was approximately at wilting point.

In conjunction with gravimetric determinations of soil moisture, the electrical resistance method has been tried, first with Baird and Tatlock's gypsum blocks made according to H. C. Pereira's design, and later with a modified form of the nylon units originally developed by Bouyoucos (1949 and 1952). The latter was more sensitive than the former at the wet end of the range. Nylon units are now available cheaply and in quantity, and it should be possible to follow the actual available water throughout the year without disturbing the soil profile.

Crop Husbandry

BY

A. N. PRENTICE.

The season was dry (see Table 1), and crop establishment was uncertain. This was well illustrated by the fate of cotton early planted on new land (Nalumuli 47-50, 8 acres in all). The whole area was planted on June 9th. There was an irregular early germination followed by germination of the remaining seed after rain about July 20th. Half the area (strips 47 and 48) was ploughed out and reridged. It was resown under good moisture conditions on August 1st, and germination was rapid and even. Nevertheless, the irregular early sown area yielded 920 lb. seed cotton per acre, whereas the even growing late sown area only gave 537 lb. per acre.

Weed control was comparatively easy, and in the only weed control trial (on "lumbugu", *Digitaria scalarum*), control resulted in yield increase, presumably as a result of the saving of transpiration losses.

A trial of ridge *vs.* flat cultivation gave no significant differences in yield, but a mulching trial carried out by the Plant Breeding Section showed useful differences. Maize was grown on tied ridges in the first rains, and gave a good yield. Cotton followed (late planted on tied ridges), and the maize stover was used as a furrow mulch on half the plots, the other half being left bare. Yields were: "Mulched", 410 lb., "Bare", 308 lb. seed cotton per acre.

Rotation Trials.

In planning trials "rotation" is used to cover crop sequence in the first and second rains of the same year, as well as in successive years of the same arable break, and also the alternation of ley and arable. Trials have been designed and laid out on 27 acres of land cleared in 1952. They are planned to include, either from the beginning or at a later date, some aspects of crop and land management and farm practice.

Preliminary trials have narrowed down the crops to be included to comparatively few. Cotton is naturally our first interest. Maize, beans and groundnuts are the most important alternatives, but cassava and sweet potatoes are also included. These crops, which include all the staple crops of Buganda except the small grains and the perennials. are without exception post-Columbian introductions to Africa from the New World, so that the husbandry problem is not in fact to fit one new crop—cotton—into an indigenous system, but to devise a system made up entirely of introduced crops.

For the ley breaks, Rhodes grass, *Chloris gayana,* will be used. Elephant grass, *Pennisetum purpureum,* is the natural grass climax, but is ruled out because it is difficult and laborious to manage, and is very liable to harbour vermin. Enough work has been done on other pasture-type grasses to show that several are promising, and some of these may be introduced later, either in pure stand or in mixtures. Meanwhile Rhodes grass has the advantages that it is known to make a useful ley, and seed is obtainable in bulk by arrangement with the Serere Station of the Department of Agriculture.

Cultivations keep as far as possible to farm routine. 3 ft. tied ridges are standard. Design has been kept as simple and flexible as possible, and plots are large ($\frac{1}{8}$ acre) to facilitate modification, or such elaboration as split plot treatment.

The trial is laid out in five series linked by a common treatment. The common treatment is short term maize in the first rains, followed by cotton in the second rains, repeated annually.

The five series may be summarised as follows:

Series 1. First rains treatments to precede cotton: Groundnuts, beans, sunnhemp, bare fallow.

Series 2. Non-cotton sequences, including two strains of maize (short and long term), groundnuts, beans, sweet potatoes, and bare fallow.

Series 3. Varying frequencies of cotton with two strains of maize, groundnuts and beans.

Series 4. A six year rotation with 2, 3, or 4 years arable and 4, 3, or 2 years ley. Arable break always maize followed by cotton.

Series 5. Crops difficult to fit into standard farming operations. Cassava and sweet potatoes with maize and cotton.

Cotton Planting Date Trial.

Orthodox planting date trials are open to the objection that late plantings may suffer undue insect bombardment from adjacent earlier plantings. Various methods of meeting this objection are possible; one, used this year, is to have very large planting-date plots, permitting a large discardable barrier at harvest. Using MU8 × BP52[2] seed, a 4 × 4 Latin square trial was laid out on the Lukuba section of the station, covering 4 acres and giving plots of $\frac{1}{4}$ acre gross. No "unfair" spread of *Lygus* into the much smaller harvested centres of the plots was noted, for what the observation is worth. American bollworm attack, although fairly heavy, apparently originated from outside sources, and jassid attack, as usual, was quite negligible.

The trial, although on a low level of yield, adds further formal evidence to the general experience of this and most other seasons that yield drops markedly with advancing planting date.

	Date planted.	Germination.	Yields per acre, lb. seed cotton
Early planting.	23.6.53	Delayed about 44 days	613
Second planting.	9.8.53	Normal get-away	580
Third planting.	26.8.53	Normal get-away	403
Fourth planting.	11.9.53	Normal get-away	259

Dates highly sig. SE ± 34.61. L.S.D. at 5% level 85 lb. per acre.

The early planting, on June 23rd, just missed establishment rains and stayed dormant almost until the time of the second planting—itself determined by rainfall—when both groups got away virtually together and yielded much the same amount. The eventual stand of the first planting was excellent although the seed spent more than 40 days in the soil. All seed was acid-treated.

The importance of current rainfall in ensuring establishment at planting is strikingly emphasized by the failure of the first planting to germinate and thus use its potential advantage. The trial was surrounded by 6 acres of a machine-planted bulk of the same strain planted 19th to 21st June, only a few days before the first planting

of the trial, but this bulk "got away" normally and yielded at well over twice the best rate in the trial.

Four spacing treatments superimposed on the four planting dates of this trial gave a barely significant advantage to the three closer spacings as a whole over the widest (3 ft. × 2 ft.), and there was no date × spacing interaction.

Manuring.

A 10-acre field in its third arable year, in Nalumuli section, was used for a trial with farmyard manure on two bulk crops, maize succeeded by cotton. The manure was applied by distributor, on plots 1000 ft. long × 18 ft. wide, and the application was judged to be even enough for comparative work. The rates 0, 5, and 10 tons per acre were used on both crops, spare 0 plots being used for the manuring on the second crop so that this second crop had both direct and first residual treatments.

The maize crop was reasonably successful, with an overall average of 2000 lb. per acre of dry grain; the following cotton crop, planted as late as 29th August, gave the miserable overall yield of 240 lb. per acre seed cotton. The near-failure of the cotton crop—in spite of a good stand and nothing out of the ordinary in the way of insect attack—must be attributed to late planting on land which had been sucked dry by the preceding maize crop and then received only some 10″ of rainfall during the course of the cotton crop.

Farmyard manure made no difference to the maize yields; slightly better growth was noted on the manured plots during development but the final yields of the treatments were the same. The cotton, again, showed signs of slightly better growth at some stages, under manuring, but a resultant increase of 40 to 50 lb. per acre seed cotton—from both residual and direct manuring—was not worth the labour involved and in any event was barely significant at the 5% level.

This same trial had sulphate of ammonia treatments at 200 lb. per acre superimposed, similar on both crops. Application was made at planting and at 10-day intervals up to Day 70. The maize crop suffered in yield from the applied nitrogen: all dates averaged about 18% less grain than the controls. There was no question of reduction in stand by faulty placement: all fertiliser was applied to the side of the ridge. Applications at Day 20 and Day 30—probably around the best times to apply nitrogen to maize in wetter seasons—were elaborated to include double dosages, but although that at Day 20 brought yields back nearly to the level of the controls, that at Day 30 depressed yield to the second lowest level of the dozen treatments in the trial.

In the cotton crop, nitrogen re-applied on the same pattern made no difference one way or the other to yield at the single-rate level and

gave an indication of a slight increase (8) at the double rate, not worth bringing to account at the very low standard of yield.

Cultivation Methods.

The 4-acre "Exhaustion" area of cotton went in late following the application of TCA for lumbugu (*Digitaria scalarum*) control and the overall yield was not good at 486 lb. of seed cotton to the acre. There was no difference between "Flat" and "Tie-Ridged" methods of cultivation, and this as a generalization applies to other trials of the two methods on other crops, in both cropping seasons of the year. Some rill erosion was noted on the Flat plots, but this with its concomitant run-off of water has seemingly not yet told on yields.

Verticillium wilt was particularly severe, and indeed has reached such a point that most of the site will be put under wilt-resistant types in future in an attempt to clear the soil of the infection. Wilt incidence has been plotted plant by plant over two seasons, and the area may be of use in field studies of the disease.

Maize Work.

Maize in the first rains yielded fair to good crops, but in the second rains—i.e. the cotton growing season, but a time when some maize is often successfully grown—yielded poorly, doubtless due to decreasing soil moisture.

Time-to-harvest of the three varieties Kawanda 8, Muratha and Yellow Coast showed little change from the previous year, the varieties taking 119, 132, and 150 days respectively, with Muratha showing up as 10% better in yield at the 2500 lb. per acre level. Yellow Coast, probably the yield leader when moisture is not critical, fell back to the level of the small K8 variety. The late-maturing "growthy" Yellow Coast responded to spacing in the opposite way to K8, as might be expected in the particular season, wider spacing giving the better result with the big, and closer with the small variety. The intermediate Muratha responded to spacing in much the same way as K8 in the first rains, but in a trial on its own in the second rains, in the greater drought, showed a big drop in yield from the widest to the closest spacing. Maize is more sensitive to spacing than cotton. Close cotton spacing of the order of 15,000 to 30,000 plants per acre will rarely be outyielded by wider spacings such as 7,500 plants to the acre, and will usually be the better whatever the season, whereas maize populations of the same range yield better at close spacings in wetter seasons and at wide spacings in drier seasons.

Mass selection within Muratha has given quick results, judging by first trials. Selection was for generally sound plants, with particular pressure towards early maturity. A second-rains trial showed

"Selected" well ahead of "Ordinary" although on a low plane of yield. Testing of various breeding techniques is normally slow work, but progress is being made in the provision of material of different intensities of in-breeding, and Namulonge is fortunate in being able to work on two generations of maize in the calendar year.

Weedkillers.

Attention was again concentrated on the practical problems of ridding fields of the couch grass *Digitaria scalarum* by sodium trichloroacetate (TCA). Treatment of whole fields by spraying machinery or of infested "spots" by watering cans has controlled the weed using the heavy—and expensive—rate of about 75 lb. of TCA to the acre.

In the dry 1952-53 season, the safety margin between application and subsequent planting suggested in the last report ("4-10 weeks depending on the weather") was quite inadequate, as crops on Namulonge have shown typical TCA symptoms half a year after land had been treated. A first crop of maize, planted in March 1953 three months after TCA treatment, germinated well and then went down disastrously with typical TCA distortion. It was replanted to beans, which made splendid growth until they in their turn went down almost overnight with TCA symptoms, presumably as the roots reached a poisoned layer. The highly soluble TCA probably only moves downwards as far and as fast as percolation will take it: percolation beyond 10 ft. evidently did not occur after the TCA was applied at the end of 1952, and even the $6\frac{1}{2}''$ rainfall of April 1953 could not have moved it below the root reach of a vigorous bean crop. The TCA was seemingly still as chemically active as ever after six months in the soil.

Soil Chemistry

BY

P. H. LE MARE.

The establishment of a chemical laboratory has made slow progress owing to delays in shipping equipment and chemicals from England. Sufficient chemicals have now been obtained locally to make a start in soil and plant analysis, and in training assistants in laboratory routine.

In the field a number of pits have been dug, mostly in the south-eastern part of the station. In general the surface soil is a dark reddish brown becoming red and then yellowish red with increasing depth. The underlying rock is either granite or mica schist, and may

occur at about 3 feet below the surface on the crests of the ridges, increasing to about 30 feet or more on the lower slopes. The deepest pit, on the lower slopes, reached 27 feet without encountering rock. Quartz pebbles, mostly rounded, have been found in bands in most pits. These may occur at or near the surface or at any depth down to 24 feet.

Plant Physiology

BY

H. G. FARBROTHER.

Growth and Development of the Cotton Plant.

Records were taken on the growth of early, mid and late germinated cotton. In addition to records taken last year, data were collected on boll size, on an arbitrary scale based on boll diameter, and on petiole weight which was formerly included in stem weight. Grading of bolls by size has been introduced to help in the interpretation of the compensation that takes place following early crop loss, and in order to follow the rate of boll setting in relation to the flowering curve. These records are complementary to those carried out by the Lint Physiologist. Records of petiole weight were initiated as a step towards estimating total loss of dry matter to the plant on the abscission of the leaves. It remains now to improve the methods of estimating length of individual leaf life.

Timing, Cultivation and Soil Moisture Reserves.

The early planting on 9th June germinated irregularly owing to the poor rainfall. In an area of 4 acres, however, large plots of reasonably uniform stand were demarcated satisfactorily to provide the "Early" comparison with 1951-2. Similar plots of "Mid" date were demarcated in areas of the same field which germinated uniformly on or about 20th July. The "Late" plots were planted on an adjacent field of similar history on 1st August. The land used for this experiment was in the first year after opening from elephant grass. At the time of ploughing, in April, the soil moisture status under a similar grass cover was such as to provide 18-20 inches of available water in a 10 ft. profile. Rainfall was sufficient to maintain the quantity stored at about this level through May. Thereafter, however, the top soil dried out to a sufficient depth to cause the irregularities in germination. Nevertheless, as soon as the roots had developed sufficiently to tap the subsoil reserves, growth was rapid and apparently unaffected by the exceptionally low post-sowing rainfall.

Comparison of "Early" 1952-53 with "Early" 1951-52.

The growth rate, in terms of log. oven dry wt. in grams per plant may be compared graphically for the two years. Fig. 2 shows that the general slopes of the log growth curves are similar, but the displacement is quite marked, being maintained throughout the season. The initial advantage of 1952-53 over 1951-52 cannot be adequately explained, as records have not been obtained for the seedling stages. Future observations must include these early data. The difference may be due in this case solely to planting date, but whatever the cause, displacement of the growth curve in this manner is very relevant to the study of inter-seasonal effects. The comparison of the two curves for the months of November and December (Fig. 2) is of considerable interest, though difficult to understand. In the absence of comparable soil moisture data it is impossible to disentangle the response to water strain from the response to internal factors resulting from the maturing of the crop. These two important factors are completely confounded within the two years, 1951-52 being a year of high rainfall in October, November, and December, and a moderate crop (48 gm. per plant), and 1952-53 a year of low rainfall with a heavy crop (73 gm. per plant). Soil moisture studies on a field scale are in hand, and it is hoped that the 1953-54 records will be supplemented by continuous soil moisture data.

The build up of total leaf area from the component parts, i.e. main axis, monopodia, sympodia and secondary sympodia leaf areas, appears at this stage to be less interesting than originally thought. The contributions to total leaf area reflect the fruiting habit of the plant, the ratio of sympodia leaf area to secondary sympodia leaf area running parallel to the ratio of seed cotton produced on the two types of fruiting branches. Total leaf areas (Fig. 3) for the two years are most interesting. The absolute levels differ markedly between years, though temperature, humidity, radiation, and hours of sun, which are climatological factors normally associated with leaf size, do not differ markedly for the three months August, September and October, which show the widest divergence of slope of log. area curves. There may, however, have been interference by *Lygus* in 1951.

Total leaf areas can be used together with total plant weight to enable nett assimilation rates to be estimated (Fig. 4). The increase in total plant weight per unit area of leaf surface provides an index of photosynthetic efficiency. The values shown in Fig. 4 can however only be an approximation to the true N.A.R., as neither the weight of dry matter in the root system nor the additional photosynthetic area provided by the bolls and bracts is taken into account. Nevertheless, for comparisons between, and possibly within, years, nett assimilation

Fig. 2

TOTAL PLANT DRYWEIGHT

LOG GRMS. PER PLANT
(EXCLUDING ROOT)

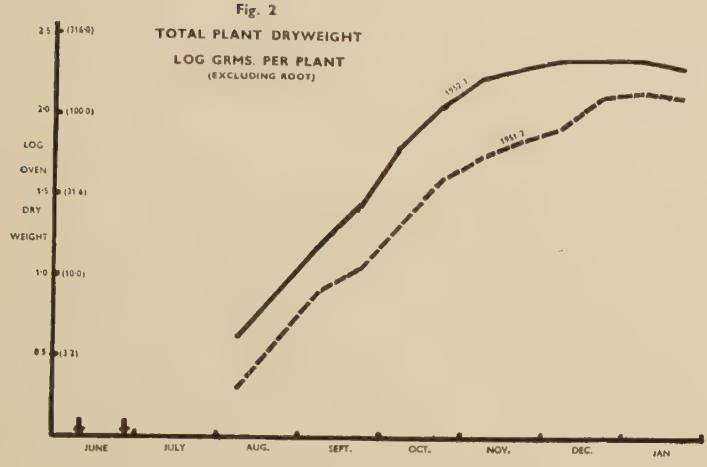


Fig. 3

TOTAL LEAF AREA

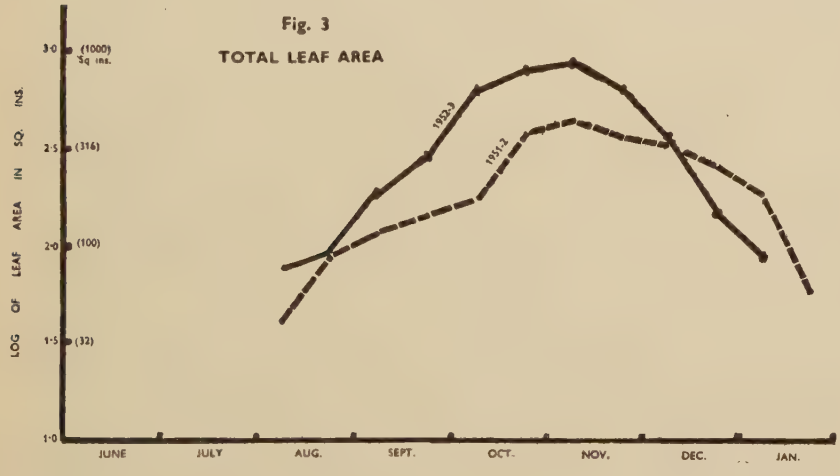
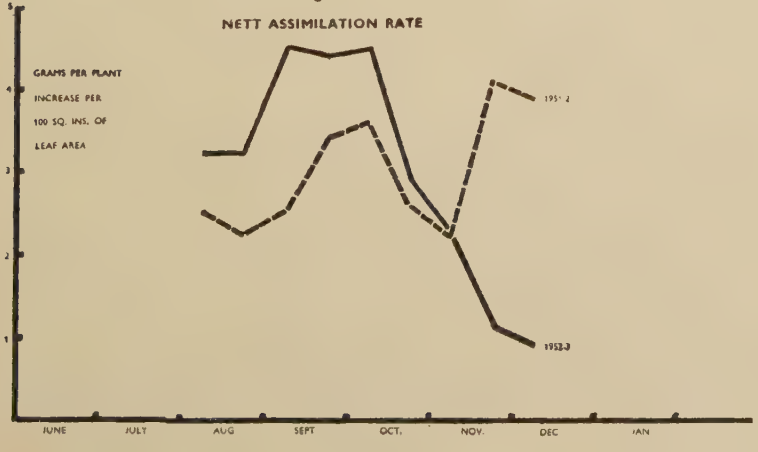


Fig. 4

NETT ASSIMILATION RATE



rate, even with the above qualifications, promises to throw some light on the problem of plant growth.

Rate of Bud Production and Cumulative Bud Production.

Figs. 5 and 6 show the comparison of bud production for the two seasons 1951-52 and 1952-53. Owing to the system in use of withdrawing sample plants from the field, the rates and cumulative totals of buds can only be estimated from the number of buds present at any one time, then correcting to actual production by means of an estimate of the period between first recordable bud size and flowering. Bud production in 1952-53 (Fig. 5) virtually ceased by mid October after a cumulative total of 70 buds per plant had been reached. In the second week of November a minor burst of bud production on some plants raised the average cumulative total to 75. In 1951-52 on the other hand bud production persisted into December. Even January (not shown) gave a small addition to the cumulative total of 55.

It was reported for 1951-52 that the production of potential fruiting points continued to rise into early January, and the large discrepancy between the total and those that could be accounted for as having carried either buds, flowers or bolls, was briefly referred to as a measure of the undeveloped buds. Considerable interest has thus been centred on the nature of the development of the flower bud in its very early stages. There is no doubt that the very early shedding of flower-buds at the "matchhead size" stage, before reaching the "recordable" stage (4-6 mm. across) is extremely important. It appears certain that some environmental factor controls the fate of the flower bud when only some 1-2 mm. in diameter. The abscission mechanism is well developed even at this stage and complete control of the fruiting potentiality of the plant is effected. There is some evidence that the factor concerned is not purely an internal factor, such as for example the weight of crop already set. Shedding of buds at the "matchhead" stage occurs at intervals even on plants from which all buds are removed as they reach "recordable" size.

Bud shedding at this "matchhead" stage appears also to be related to the internode length of sympodia and secondary sympodia. For 1952-53 on BP52 the average internode length, where a boll or flower or even a well developed bud was carried, was 2-4 inches. Where "matchhead" shedding had occurred, the internode length dropped to as little as $\frac{1}{8}$ inch. Unfortunately no measurements of internode length were recorded for 1951-52 to indicate this relationship in a wetter season. From the cumulative bud production and the total fruiting point curve for 1951-52 it can be deduced that some 50 per cent. of the total fruiting points were shed in this manner. In 1952-53 the percentage was only a little lower, 45 per cent. of total fruiting points being

shed at "matchhead" bud stage. In view of the wide difference in moisture availability in the two seasons, simple water strain does not appear to be a likely cause on the slender evidence so far collected. Towards the end of the bud production curve it might be guessed that those plants carrying a big crop would show low figures for buds present, and the reverse for comparable sized plants with a small crop set. Examination of the 1952-53 data shows no such relationship. The ratio for buds to bolls for the month of October appears to be entirely random. This lends further support to the hypothesis that internal factors alone do not control the rate of flower production.

Comparisons of Times of Planting within the Season 1952-53.

Comparisons given in Fig. 7 of log. growth curves (oven dry wt.) for the three times of planting show steeper maximum slopes for the later dates. The point of inflection of the "Mid" occurred in late October, the curve thereafter resembling the "Early" but at a lower level. The "Late" planting maintained rapid growth until the end of November when increase in total plant weight virtually ceased. Interpretation of the initial "get away" by plants of different planting date is of some local interest, and an attempt to include early root development in calculations of nett assimilation rate might be needed if log. weight growth curves are studied from origin.

Leaf area measurements, compared in Fig. 8, show the steepest increase in leaf area for the late planting. Fig. 8, of course, shows the log. of leaf area present on the plant for the particular fortnightly period. (An average of approx. 20 plants.) Obviously, then, the integration of leaf area and time will give a measure of the total photosynthetic potential of the average plant at the three times of planting. This product of leaf area and time is recorded in Table 4 as "square foot weeks." Considering this figure as an estimate of the productive capacity of the plant, it is of interest to compare the ratios of seed cotton weight and total final plant weight to "square foot weeks" of leaf area for the three planting dates. It will be seen that the ratio remained fairly constant over the three dates, suggesting that within this season the productive capacity of the plant was in fact fairly indicated by the "square foot weeks" of leaf area it produced.

Fig. 9 records the development of seed cotton through the season for the times of planting. The weight of seed cotton in grams oven dry matter refers to the total, including that dissected from green bolls as well as that opened normally. These measurements form another link with the Lint Physiology work. The rate of bud production, Fig. 10, shows that the peak rate of bud production increases slightly with delayed planting but the cumulative total (Table 4), although comparable for "Early" and "Mid," has fallen with August planting to 63 % of the "Early" figure.

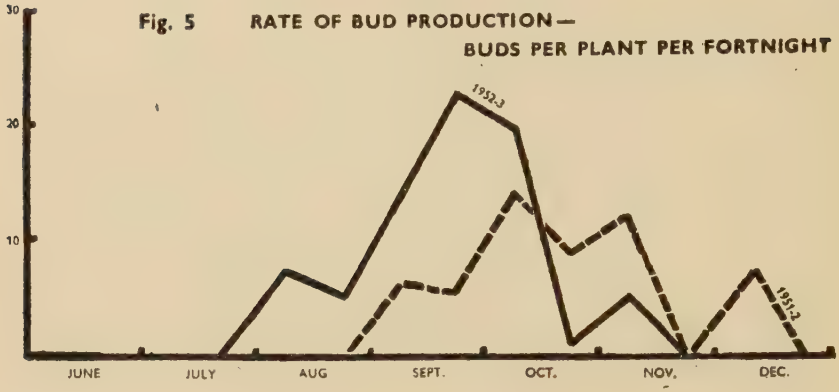


Fig. 5 RATE OF BUD PRODUCTION—
BUDS PER PLANT PER FORTNIGHT
30
20
10
1952-3
1951-2
JUNE
JULY
AUG
SEPT.
OCT.
NOV.
DEC.

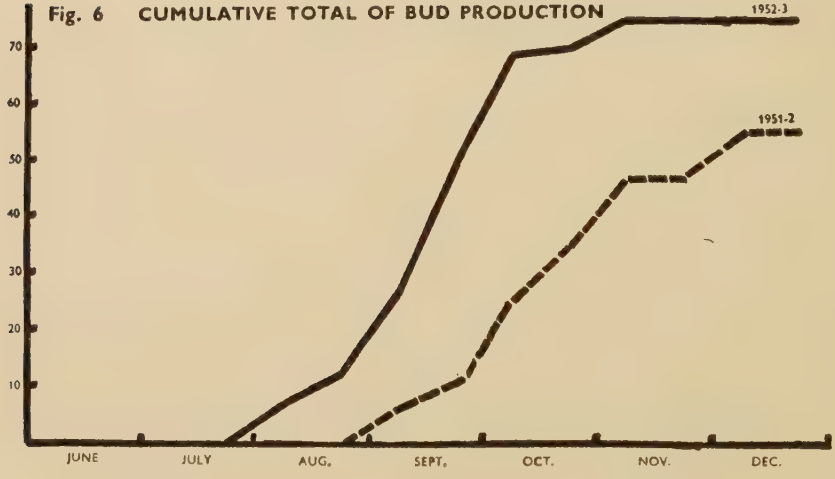


Fig. 6 CUMULATIVE TOTAL OF BUD PRODUCTION
70
60
50
40
30
20
10
1952-3
1951-2
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.

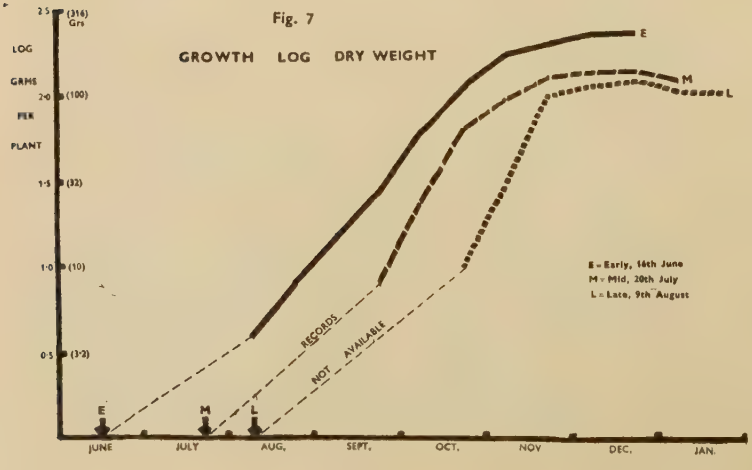


Fig. 7
GROWTH LOG DRY WEIGHT
LOG GRMS PER PLANT
2·5 (316) Grs
2·0 (100)
1·5 (32)
1·0 (10)
0·5 (3·2)
E
M
L
RECORDS NOT AVAILABLE
E = Early, 14th June
M = Mid, 20th July
L = Late, 9th August
JUNE
JULY
AUG.
SEPT.
OCT.
NOV
DEC.
JAN.

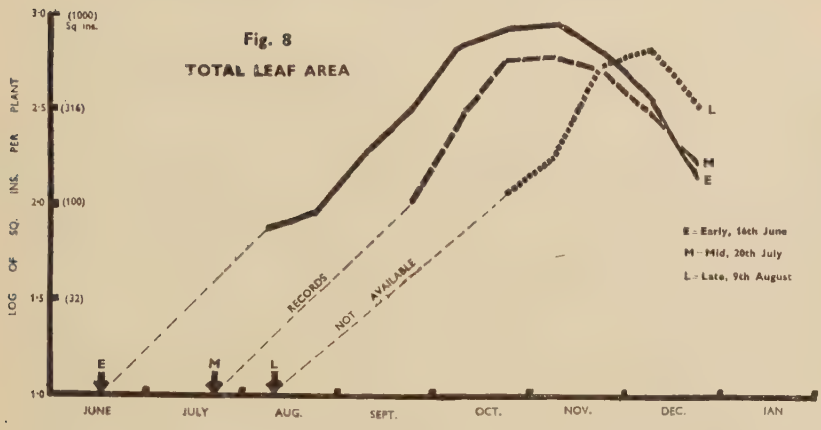


Fig. 8
TOTAL LEAF AREA
LOG OF SQ. INS. PER PLANT
3·0
2·5
2·0
1·5
1·0
(1000) Sq ins.
(316)
(100)
(32)
RECORDS NOT AVAILABLE
E
M
L
E = Early, 16th June
M = Mid, 20th July
L = Late, 9th August
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN

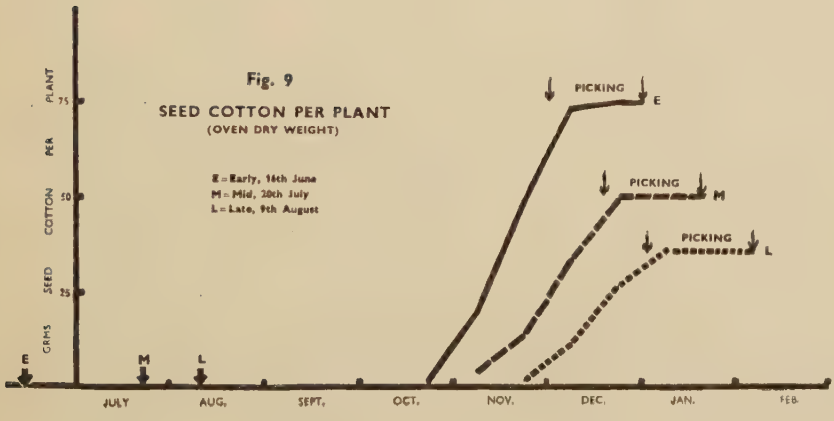


Fig. 9
SEED COTTON PER PLANT
(OVEN DRY WEIGHT)
GRMS SEED COTTON PER PLANT
75
50
25
E = Early, 16th June
M = Mid, 20th July
L = Late, 9th August
PICKING E
PICKING M
PICKING L
E
M
L
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.

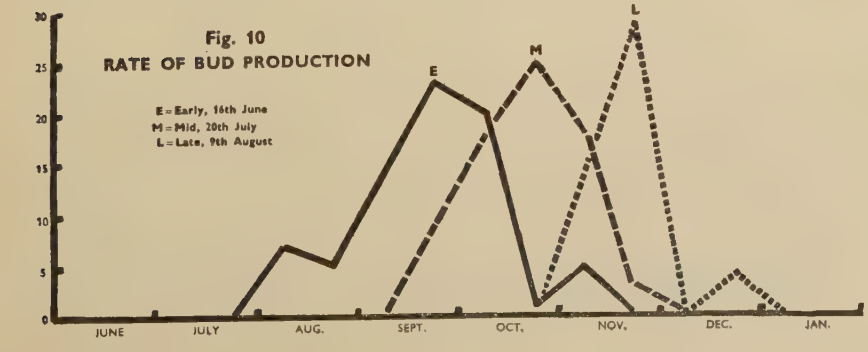


Fig. 10
RATE OF BUD PRODUCTION
30
25
20
15
10
5
0
E = Early, 16th June
M = Mid, 20th July
L = Late, 9th August
E
M
L
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.

Table 4.

Comparison of certain data from records on time of planting observations.

	Early.	*Mid.*	*Late.*
Maximum Leaf Area (sq. ins.) (Av. of 10 plants).	945	708	776
Date Recorded (week around)	Nov. 4th	Oct. 27th	Dec. 4th
Final Yield of Seed Cotton per plant (Oven dry).	73 gm.	50 gm.	36 gm.
First picking date.	1st Dec.	16th Dec.	1st Jan.
Final picking date.	1st Jan.	16th Jan.	4th Feb.
Total Final Plant wt. (oven dry, excluding roots).	225 gm.	135 gm.	125 gm.
Stem wt. per plant.	79 gm.	40 gm.	48 gm.
Cumulative Totals, per plant			
(a) Bud production	75	73	47
(b) Flower production	69	47	42
(c) Boll Product (incl. bolls 2 days old).	32	19	21
Bolls harvested, mature	23	13	12
Nodes on Main Axis	26	22	23
Leaf Area integrated with time (in sq. ft. weeks)	58·4	36·6	32·4
Ratio of Seed Cotton / Sq. ft. weeks.	1·25	1·36	1·11
Ratio of Total Plant Wt. / Sq. ft. weeks.	3·85	3·69	3·86
Ratio of Seed Cotton / Stem wt.	·924	1·25	·75

Lint Physiology

by

J. P. Evenson.

Observations reported last year were repeated under the much drier conditions of 1952-53, and interesting differences were recorded. Maturation periods of S47, BP52, 3MB, and MU8 × BP52[2] were shorter than for comparable flowering dates last year by 15 days. The downward trend in maturation period for later formed bolls was similar to that observed last year. In spite of the reduction in maturation period, however, values for lint index and seed weight for successive flowering dates were no lower than last year.

Variation in Number of Seeds per Loculus.

In the previous season it was noticed that there was a significant linear increase in number of mature seeds per loc from early to late formed flowers. It was not then known whether this was due to an increase in the number of ovules available for fertilisation or to increasing percentage success in fertilisation as the season progressed. To elucidate this the same records were taken this season using a BP52 pedigree bulk known as NC51, and in addition records of the number of ovules per loc present on the day of flowering were taken. It was

found that the values for number of ovules per loc plotted against flowering date described a parabolic curve with its peak occurring at the same time as the peak number of open flowers in the crop. The values for mature seeds per loc plotted against flowering date also described a parabolic curve with its peak close to that of the number of ovules per loc but the values were on the average about 15 per cent. below them at the beginning of the season falling to about 30 per cent. below at the end of the season. Since changes in seed number per loc were observed within the season it is not surprising that there are overall differences between these two seasons.

Fibre Tests on the 1951-1952 Experiments.

Table 4 of the 1951-52 Progress Report gave values of seed weight, lint index and boll maturation period for bolls formed from successive weekly groups of flowers. Lint from these samples was sent to the Shirley Institute for fibre test. The results grouped by flowering dates show how the separate pickings varied in the same plot.

Table 5.

Seasonal changes in mean fibre weight and maturity ratio.

	3MB.		*S.47*		*MU8 × BP52²*	
Flowering Dates.	*M.F. Wt.*	*Maturity Ratio*	*M.F. Wt.*	*Maturity Ratio*	*M.F. Wt.*	*Maturity Ratio*
21.9 -27.9	152	0·91	153	0·88	153	0·835
28.9 - 4.10	142	0·795	153	0·85	144	0·855
5.10-13.10	—	—	150	0·835	142	0·78
13.10-20.10	135	0·745	147	0·835	137	0·81
21.10-28.10	136	0·795	145	0·85	142	0·835
28.10- 4.11	141	0·825	143	0·81	127	0·76
5.11-12.11	142	0·825	136	0·81	113	0.69
13.11-29.11	133	0·765	143	0·775	121	0·705

There was a linear relationship between log. seed weight and log. lint index. For the three strains plotted together $r = + \cdot 886$, $R^2 = + \cdot 70 = 70\%$. A similar relationship existed for log. seed weight and log. mean fibre weight or maturity ratio. Thus it appears that there is a heterogonic relationship between lint index, maturity ratio and mean fibre weight on the one hand, and seed weight on the other.

Neppiness.

The technique for estimating the susceptibility of strains to seed coat nep put forward in last year's report has been used with success by the Agricultural Department in selection for a lower rate of damage. It has now been found that the weak zone of the chalazal cap which gives rise to seed coat neps also produces the most immature hair on the seed. This is in conformity with the observation by Iyengar (1941) that the chalazal end of the seed had the least mature hair as well as the longest hair. The differential dyeing technique of Goldthwaite and

others (1947) shows up this tuft of hair well against the rest of the hairs, and its close association with the chalazal cap (weak zone) can be easily demonstrated.

The fact that there is variation in maturity over the seed surface is of interest because it seems that tangled neps must arise from tufts of immature and dead hairs, rather than from such hairs distributed at random. Thus it is most likely that the source of seed coat neps is also one of the most important sources of tangled neps.

If proneness to nep may be regarded more as a matter of distribution than of amount of immature fibre, anomalies in the relationship between immaturity count and neppiness become explicable. Moreover it is then apparent that evidence on proneness to nep should be sought in the characteristics of seed cotton rather than of lint. To test this hypothesis, maturity tests were carried out on the chalazal region and the rest of the seed separately on three Uganda strains, S47, BP52.3MB, and BP52.C(50)20. Data are given in Table 6.

Table 6.

Maturity counts on chalazal tufts and remainders on S47, BP52.3MB. and BP52.C(50)20.

Strain	*N-D for Chalazal tuft.*	*N-D for rest.*	*Chalazal tuft weight mgms.*	*Weight of rest mgms.*	*Total Calculated Maturity ratio.*
S47	1-27	27-14	7·5	40·2	·737
BP52.3MB	0-28	18-20	8·0	49·0	·714
C(50)20	19-20	21-8	7·3	46·2	·756

The values in the last column were obtained by weighting the maturity ratio for the chalazal tuft and the rest by their relative weights per seed. Since the lint on the chalazal tuft is only about one-seventh of the whole, its immaturity count is masked by that of the remainder, and the total values for maturity ratio are not very different, whereas in fact the actual distributions of immature hairs on the three samples of seed differ widely. S47 and 3MB have a much greater proportion of immature hairs in the chalazal tuft. In S47 the chalazal cap often breaks away and a seed coat nep is formed, but if the seed coat weakness was eliminated it might well be that the low maturity count at this point would make it a cotton prone to form tangled neps. BP52.3MB has been included for this reason. It is not very prone to seed coat neps but is classed as producing a neppy and unlevel yarn in spite of the fact that its maturity ratio is usually fairly high. In fact, the yarn appearance of each of these strains is concordant with the values shown here for chalazal maturity, being poor for S47 and 3MB and good for C(50)20.

Entomology

BY

Q. A. GEERING AND K. S. McKINLAY.

The entomological work has gone on for three seasons, and it is now possible to define more clearly the local problems set out in the 1950 Report by E. O. Pearson, to re-assess their relative importance, and to outline the organisation of investigations in the future. When planning the Namulonge programme it was concluded, on the basis of earlier work by entomologists in Uganda, that the main local problem to be studied in the field was the effect of *Lygus* on the cotton crop. Consequently the field work has been concentrated on studies of the bionomics of *Lygus,* and its effect on crop production. The bionomic aspect is continuing, and this involves principally the taking of population records from year to year on wild and cultivated alternate host plants and on cotton, in an attempt to ascertain the reasons for seasonal and local variations in populations on the cotton crop. The wild host which Taylor considered most important in Buganda, *Pseudarthria,* is being studied in this respect, and of the cultivated crops, beer sorghums, gram, and cowpeas are under observation. In 1952, the main immigration of adults to cotton in early August coincided with the ripening of *Pseudarthria* fruits, and diminution of *Lygus* numbers on this host.

McKinlay (1953) has summarised the results over the three seasons of the attempts to estimate the effect of *Lygus* on cotton yields. In attempting to do this, a new experimental design, a "Single-row method", was devised which overcame the difficulties of interference experienced last year with 1/40th acre plots in a normal randomised block layout. The design is essentially a randomised series of 20 yard lengths of row (separated by at least 6 rows of untreated cotton), where DDT spray is applied to run-off each week. The deposit repels the *Lygus* adults, and these plants give an indication of what the yield of the main bulk of the crop would have been in the absence of *Lygus* damage. The results to date were summed up (McKinlay, 1953) thus: "In general, the results of the 1952 experiments were similar to those carried out during the 1951 season. Under local conditions, *Lygus* had very little effect on the size of the crop, whilst an apparently light attack of bollworm later in the season reduced yields by approximately 15 per cent." The bollworm mainly involved has been *Heliothis armigera,* and with large acreages of maize being grown each year on the farm, the bionomics of this insect are also being investigated on the lines of work carried out in South Africa by Parsons and Ullyett. The field results have, therefore, pointed to the following conclusions: —

1. Under Namulonge conditions the damage inflicted by bollworms, which follow the *Lygus* attack, may be equal to or more important than the *Lygus* damage.
2. The most satisfactory method of assessing both *Lygus* and bollworm damage is by the single sprayed row technique. By repelling *Lygus,* and controlling bollworm, their separate and combined effects on the crop can be estimated by a suitable timing of sprays, since their periods of peak activity are well separated in time.
3. Variations in insect attack on different parts of the farm are so great that in order to obtain true estimates of insect damage in any year, the sprayed rows must be spread over the whole farm area. As part of a co-operative study of the causes of annual variations in crop yield, the entomology field observations will in future be carried out on experimental plots in conjunction with the crop husbandry and plant breeding sections.

In view of the finding that the cotton crop was able to make good the loss of fruiting points resulting from an early and light *Lygus* attack, but that the loss of later formed buds due to bollworm damage could not be replaced and resulted in loss of yield, the problem before the entomologists can be resolved into finding out over which period of the crop's life loss of fruiting points represents a real loss of crop, and determining which insects are responsible. This problem will require several years' repetition, in order to determine the annual range of insect losses under varying seasonal conditions. The single sprayed-row method provides a convenient means for doing this.

It is clearly of importance to the Uganda cotton crop as a whole that the technique devised for estimating these losses should be extended further afield. Similar experiments with the single-row method were repeated by officers of the Department of Agriculture, on Serere Experiment Station. This is in the Eastern Provinces where *Lygus* attacks are heavier, and the 1952 results show large increases in bolls per plant as a result of spraying over a period of 4 months. These results, however, like the Namulonge results, cannot be accepted without direct test as indicative of the state of affairs on the peasant crop. Until a detailed survey of the insect losses on the peasant crops has been made, it will not be possible to say in how many places, or in how many years, a level of damage is sustained which, if controlled by insecticides, would give a profitable increase in yield. Such a survey would ideally involve selecting large numbers of peasant cotton plots, and laying down the single-row design of insecticide experiment on these. It might be that the cost of equipment, insecticide, and labour would be considered prohibitive, but at present it would be the simplest reliable method for obtaining accurate estimates of losses. There are hopes, however, that

it will be possible, making use of the records obtained on Namulonge, to correlate an easily measured feature of insect damage with loss of yield, and to obtain counts of this symptom over a wide area. The symptoms which are being examined are the leaf-tattering and loss of fruiting points caused by *Lygus*, and flared squares following bollworm damage. Preliminary comparisons of these symptoms with yield encourage the hope that a suitable correlation will eventually be possible.

The two primary items of the programme as laid down in the 1950 proposals, namely studies of *Lygus* and basic insecticidal work, have therefore been modified. The information from field experiments has produced a method for using insecticides simply as tools for assessing insect losses in general, and has also shown that particular attention must be paid to bollworms as well as *Lygus*. It is felt that this estimation of losses is a necessary prerequisite to any refinement of a particular method of control by insecticides.

The more basic biological work has continued on a small scale during the past year. The host ranges of *Lygus vosseleri* and *Dysdercus superstitiosus* have been studied, and it is apparent that *Lygus* breeds most successfully (based on nymphal development) on leguminous and graminaceous hosts, and is least adapted to cotton. With *D. superstitiosus*, exactly the reverse occurs. It has now been demonstrated that this species is able to breed on young milky grains of sorghum and maize, and young pods of cowpeas. Its adaptability to these, however, based on fecundity and nymphal development, is least on cowpeas, greater on maize and sorghum, but low on all compared with cotton. The biological importance of these differences is worth further study, and the suitability of different aged tissues of the cotton plant for both species should be examined. With *D. superstitiosus* it has been found that fecundity of females kept on bolls of different ages increases with the age of bolls to a maximum at 8 weeks, which, however, was less than on stored ginned seed. These results suggest that the factors necessary for successful oviposition not only vary between different host plants, but within different aged tissue on any one plant.

Plant Pathology

BY

G. M. WICKENS.

Bacterial Blight (*Xanthomonas malvacearum*).

Methods of seed, stem and boll inoculation as previously advocated and with possibly useful modifications were tested on an extended scale. Four varieties were used, and varietal resistance was similar to that observed in previous years. In the seed inoculation trial, the susceptible variety SUS7/2 suffered a heavier attack when fuzzy seed

was inoculated than when acid treated seed was used, thus reversing the result obtained last year. With acid treated seed, removal of air from the container (evacuation) at the time of inoculation led to increased infection. Unexpectedly, the converse was the case with natural fuzzy seed. Evidently the mechanics of inception of seedling infection from contaminated seed need much further study. In the meantime, earlier recommendations for seed inoculation, as a method in breeding for resistance, need modification. It is now apparent that neither preliminary acid-delinting nor evacuation of fuzzy seed soaking in suspension will necessarily reduce escape from infection in susceptibles. For the present, therefore, it is recommended that the method recently suggested (Wickens, 1953) be followed, with omission of the evacuation process.

In stem inoculation experiments, variations in placement and type of inoculum were tested in replicated experiments. Placement by needle prick inoculation into the uppermost readily accessible internode, or the one below, the second below or into all three, gave similar results. Placement in the uppermost was slightly better than lower down, but in conditions similar to those of the experiment at least, rather wide errors of judgement in selecting the uppermost accessible internode would lead to little or no error in selecting for stem tissue resistance.

Three types of inoculum were compared against standard plate cultures by the needle prick inoculation technique. Bacteria dried by two methods, stored for 9 months and reconstituted by the addition of distilled water proved rather disappointing. A strong suspension of growth from 8 plate cultures in 60 ml. distilled water was as effective as growth taken direct from plate cultures. If this is confirmed in further trials, it will make possible a useful economy of cultures.

In order to assess the influence of age of plant and spacing on susceptibility of stem tissues, 40-plant samples in each of 64 "pilot-plots" of A. N. Prentice's time of planting/spacing experiment were inoculated by the standard needle-prick method but using heavy bacterial suspension. The data show a strong trend to higher incidence of infection with younger plants and wider spacings.

Boll inoculations were made on about 3,000 bolls of each of four varieties. About half those inoculated were shed shortly afterwards. Samples of these were collected and examined, and it was evident that a very large part of the loss at this stage was due to causes other than bacterial attack. Of the bolls reaching maturity, some were damaged by insects and discarded. The remainder were classified for *X. malvacearum* damage. Figures are given below for mean percentages of bolls showing external infection, and mean percentages of locs to which infection had penetrated:

Variety.	*External.*	*Internal.*
SUS 7/2	66·0	25·3
BAR 7/8	69·1	35·4
Albar 49	20·0	6·7
BP52.NC51	72·3	29·9

BAR 7/8 and BP52.NC51 were at least as susceptible as SUS 7/2, both in incidence of external lesions and in penetration of infection into the locs. Albar 49 was in both respects much more resistant than any of the others.

Verticillium Wilt (Verticillium dahliae).

In experiments at Barberton in the season 1945-46, a hyaline saltant of *V. dahliae* proved much less pathogenic than its parent microsclerotial strain when inoculated into stem wounds of the susceptible U4/5143, and removal of bolls, flowers, and flower buds at time of inoculation led to greater susceptibility to both parent strain and saltant. These results were further examined, in the present season, by stem wound inoculation of a local isolate of *V. dahliae* and of a hyaline saltant from it, into the 4 varieties U4/8161 and S47 (susceptible), B 181 (resistant), and V 135 (*G. barbadense,* very highly resistant). The influence of removal of bolls, flowers and flower buds, and of partial and complete removal of leaf, were also examined. In the susceptibles, the hyaline saltant proved only slightly less pathogenic than the parent microsclerotial strain; the difference was wider in the resistants. There were no appreciable differences between plant treatments (which were applied on the day after the inoculations), in severity of disease. Differences between these results and those obtained at Barberton are probably due to conditions in the Uganda experiment being much more favourable to disease development than in the Barberton experiment, as shown by much shorter incubation periods and a much higher proportion of plants infected.

Plant Breeding

BY

J. B. HUTCHINSON, D. MACDONALD AND H. L. MANNING.

Bacterial Blight Resistance.

Three breeding stocks were under selection for resistance to bacterial blight:

(1) Self-bred lines of Albar 51 selected out of Funtua Allen during the two previous seasons.

(2) Hybrid stocks out of an F_1 of Albar 49 × BP52 backcrossed to various commercial East African varieties.

(3) Self-bred lines out of straight BP52 selected by Dr. Wickens for resistance to the stem phase of the disease in the two previous seasons.

Twenty-seven self-bred lines of Albar 51 were planted on August 12th and stem inoculated by the needle prick technique in October. Later in the season the individual plants were graded for development of the resultant stem lesions as previously described (Progress Report, 1951-52, page 23). Only plants whose gradings for lesion development were 0 and 1 were retained. Of the twenty-seven progenies only one was homozygous for resistance to the stem phase of the disease, while seven progenies were discarded as having no plants showing the required standard of resistance. Later in the season a roguing was carried out in the remaining plants on economic characters, the final result being that 131 plants from 18 progenies were carried forward as single plant selections, together with 19 small bulks.

While high resistance to bacterial blight was of paramount importance in selection within the Albar 51 stocks, it is satisfactory to record that the resistant selections also exhibited a wide range of other desirable characters, e.g., good fruiting, earliness, and high ginning outturn, allied to a wide range of lint lengths. Thus in addition to their use as parents for transference of bacterial blight resistance to commercial varieties, they also offer scope for straight selection within themselves.

The progenies of the crosses and backcrosses to Albar 49 were in all respects much less attractive, and in view of the great promise of the Albar 51 progenies, work on the Albar 49 crosses will be curtailed.

Eighteen plants from three BP52 families showing stem resistance in the previous season were grown in progeny plots, and again stem inoculated. Of the 18 progenies none proved homozygous for resistance, but only three progenies were discarded for complete susceptibility. The plants reaching the desired standard of stem resistance (grades 0 and 1) were later rogued for general field characters, and from the 15 remaining progenies, 71 single plants were carried forward for further testing in the coming season. Like the Albar 51 selections, they also exhibited a good range of other desirable economic characters and a number of the best selections will be tested in replicated progeny rows against standard BP52 in the coming season.

Progress in selection for stem resistance has been excellent in all stocks, and tests for resistance to the boll phase of the disease will be added in the coming season.

Sixteen Albar 51 bulks were planted in a field trial using BP52.5MB as control. All Albar progenies are still highly variable, but it seemed desirable nevertheless to obtain a first assessment of the general cropping capacity of the strains. The trial was planted late (August 12th), and allowing for low rainfall during the growing period the final yields,

ranging from 205 to 361 lb. lint per acre, are very satisfactory. Most of the Albar strains compared very favourably with the control 5MB and some outyielded it.

Verticillium Wilt Resistance.

A preliminary attempt was made to isolate strains within the Albar 51 group which were resistant to *Verticillium* wilt. Twenty-two Albar 51 progenies were grown and stem inoculated below ground level with cultures of the fungus. The resistant strains KP28 and B181 were used as controls. While no immune plants were found or even plants exhibiting as high resistance as the best B181 selections, there were plants which showed useful degrees of resistance. Five of the progenies were completely susceptible but from the remaining 17 progenies 86 single plant selections are being carried on for further testing. These will in the coming season be stem inoculated with bacterial blight, and those plants showing high resistance to blight will later in the season be inoculated with *Verticillium* wilt.

A number of progenies from a B181 × BP50 hybrid stock selected for resistance to *Verticillium* wilt in the two previous seasons by Dr. Wickens were re-inoculated and the most resistant plants again selected. Resistance was high, but unfortunately the general level of other desirable characters was rather low.

BP52 Material.

The breeding plots, the modal bulk, the district variety trial and some replicates of the small bulks trials were all sown late and yields were correspondingly small.

Replicated progeny rows were laid out in a randomized complete block arrangement with 48 progenies and 5 replications. Growth and development were atypical and final yield level was low for all progenies. Indeed the effect on bolls per plant and lint per plant was such that differences between progenies in strains were no greater than the error mean square. That is, "heritability" was zero for these characters. Even such traits as seeds per boll and lint per seed—normally with low proportional environmental variation—had unexpectedly low estimates of "heritability". That for seeds per boll was 0·206 and for lint per seed 0·668. The resulting selection index based on the discriminant function technique, with a selection differential based on 8/44 progenies, indicated that a yield advance of about 17 per cent. should be expected from the 1953-54 progenies. If such an advance be obtained the cumulative yield advance would be of the order of 47 per cent. over the original material from which the first selections were made in 1948-49. Since the original material has been kept in storage, and has this past season been grown as a selfed bulk, the direct estimation of this advance during the coming season will be of very considerable interest.

The small bulks trial was sown in four sets of three replications each, on different parts of the farm. Yield of lint per acre of the set sown before the end of June, on land not cropped in the first rains, was about 317 lb. The set sown on July 25th on the Namulonge section of the farm had the advantage of a good start with over 4 inches of rain in the month following planting, and gave 287 lb. per acre. By contrast the set sown on July 30th at Nalumuli had only 2·35 inches in the same month and gave only 255 lb. per acre. The last sowing, on August 13th, gave only 232 lb. per acre. Yield advance of the mean of 7 selected strains from all localities over the NL/52 = 4MB control, was disappointingly small, being but 2·6 per cent. Since NL/52 is expected to be about 14 per cent. better than the original bulk it may be inferred that the mean of these strains is about 17 per cent. better than the original bulk.

A first sowing of modal bulk in July led to a very poor stand. The gap-filling in August germinated very well and the final stand was satisfactory. The plants of the distinctive age groups yielded quite differently and the subsequent modal selection cannot be regarded as comparable with that exercised in earlier years.

Information relating to thirteen District Variety Trials in the BP52 cotton area was supplied by courtesy of the Agricultural Department. During the past season it was possible to test three Namulonge selections against two standards from the Kawanda breeding stocks. Of the Namulonge strains two were of the C(50) series and the third a mixture of two C(48) series. Growing conditions were in general satisfactory. At Kawanda, however, the mid-July sown trial suffered from such a severe hailstorm that it was feared it would be a total loss. A new trial was sown in September and it is of interest to record that on the earlier sown trial, in spite of stand irregularities and damage to plants consequent on the hailstorm, the mean lint yield per acre was 175 lb. compared with a general mean of 115 lb. for the September sown trial, a remarkable confirmation of the great return accruing from "timely" sowing. Data from all trials are presented in Table 7 as lb. clean lint per acre. The Mukono trial should be discounted. It was on very variable land. The plot yields differed enormously and the standard error was very high. Since the weighting of the final mean was carried out according to the precision of the trials, they are presented in this order.

Yield differences were statistically significant at four localities only. The average increment of C(50)20 over K/51 at these was of the order of 22 per cent., and over all trials about 9 per cent. Since K/51 itself is appreciably better than the commercial bulk, this increment for C(50)20 must be regarded as an indication of satisfactory progress of the breeding system.

TABLE 7.

DISTRICT VARIETY TRIALS OF BP52 STRAINS 1952-53.

ARRANGED IN ORDER OF PRECISION OF THE 5×5 LATIN SQUARES.

Locality	*Sowing Date*	*Clean Lint per Acre lb.*					*S.E.*
		Kawanda Strains		*Namulonge Strains*			
		K/51=BP52B	*R1=BAR/BP52B*	*C(50)17*	*C(50)20*	*NC/51*	*%*
Nakifuma	June 14	395	379	451	471	434	6·2
Bukalasa	July 19	360	362	414	426	392	6·3
Namulonge	Aug. 8	244	238	260	235	255	11·4
Kyanamukaka	July 12	363	368	325	343	318	12·1
Kalagala	Aug. 9	178	182	166	177	161	13·4
Bukomero	Aug. 9	278	239	243	261	247	14·3
Kawanda I	July 19	166	149	161	206	178	15·5
Bulindi	July 18	267	281	290	333	276	15·6
Nkozi	June 14	315	321	294	278	327	15·9
Kisagazi	Aug. 30	195	175	175	182	168	15·9
Kawanda II	Sept. 2	129	113	98	132	106	16·0
Kakumiro	July 26	187	172	179	245	154	19·6
Kabasanda	Aug. 5	166	142	125	202	181	30·9
Mukono	July 14	92	103	100	139	152	46·8
Unweighted Means	*Ginning Out-Turn*	32·8	32·6	34·9	33·5	32·6	
	Lint per Acre.	238·2	230·3	234·3	259·3	239·2	
Weighted Means % K/51		100%	95·7%	99·3%	108·6%	99·0%	
4:1 Limits of Yield	*Upper*	365	361	384	397	373	
	Lower	111	99	85	121	105	

YIELD ORDER WHERE DIFFERENCES STATISTICALLY SIGNIFICANT.

Nakifuma	*C(50)20*	*C(50)17*	*NC/51*	*K/51*	*R1*
Bukalasa	*C(50)20*	*C(50)17*	*NC/51*	*R1*	*K/51*
Kawanda I	*C(50)20*	*NC/51*	*K/51*	*C(50)17*	*R1*
Kakumiro	*C(50)20*	*K/51*	*C(50)17*	*R1*	*NC/51*

$p = < 0{\cdot}05$

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